

CLAIMS

1. A power-splitting infinitely variable transmission with two modes of operation, wherein the constituent elements thereof are distributed between two power trains connecting the internal combustion engine (1) in parallel manner to the wheels (3) of the vehicle, these means including two epicyclic gearsets (5, 6), two electric machines (2, 4), one reducing stage (7) and adjusting means that distribute the power between the two power trains differently depending on the mode of operation thereof, characterized in that it is provided with a primary power train on which there is disposed a compound gearset (136, 137), a secondary power train provided with an epicyclic gearset (141, 142) associated with each electric machine (131, 132) of the electric variator, and a mode-changing system for selectively immobilizing at least one spinning element of one of the said epicyclic gearsets associated with one of the said electric machines, in such a way that at least one mode of operation of the infinitely variable transmission is selected among a plurality of modes of operation.

2. A transmission according to claim 1, characterized in that:

the internal combustion engine (130) is connected via a reducing stage (136) to the ring gear (C2) and to the planet carrier (ps) respectively of a first epicyclic gearset (137) and of a second epicyclic gearset (138) of the gearbox (134) proper;

the vehicle wheels (133) are connected to the gearbox (134) via a reducing stage (139) of gear ratio K_0 , one access of which is coupled respectively to the planet carrier (ps2) and to the ring gear (C1) of the first epicyclic gearset (137) and of the second epicyclic gearset (138), the first and second epicyclic gearsets (137 and 138 respectively) constituting a compound epicyclic gearset disposed on the primary

power-splitting pathway.

3 - A transmission according to claim 2, characterized in that the first electric machine (131) of the electric variator is connected to a reducing stage (140) coupled to the sun gear (p2) of the first epicyclic gearset (137) and to the ring gear (C1) of a third epicyclic gearset (141), the sun gear (p) of which is coupled to the ring gear (C) of a fourth epicyclic gearset (142), the sun gear (p) of the third epicyclic gearset (141) and the ring gear (C) of the fourth epicyclic gearset (142) being connected to the frame (145) via a brake (144'), and in that the planet carrier of the third epicyclic gearset (141) is itself coupled to such a fixed point (145) by means of a brake (144).

4 - A transmission according to claim 2, characterized in that the second electric machine (132) of the electric variator is coupled via a reducing stage (143) with gear ratio K_{e2} to a fourth epicyclic gearset (142) by its sun gear (p).

5 - A transmission according to one of the preceding claims, characterized in that the reducing stage (136) is provided with a pinion (154) engaged with a toothring (155) mounted on a bearing that is free to rotate around a central gearbox shaft (156) integral with the planet carrier (159; PS1, Fig. 3) of the second compound epicyclic gearset of the primary power train, and the planet carrier (159) of the first epicyclic gearset (138) is integral with the ring gear (175) of the second epicyclic gearset (137), the ring gear (161) of the second epicyclic gearset (138) being connected to or integral with the planet carrier (161).

6 - A transmission according to claim 5, characterized in that the wheels of the vehicle are coupled on a shaft (153) via a pinion (158) to a toething (157), integral with the ring gear (161) of the second epicyclic gearset (138).

7 - A transmission according to one of claims 5 or 6, characterized in that:

the secondary power train is provided with third and fourth epicyclic gearsets (141) and (142) respectively, for coupling it to the variator, to the mode-changing system and to the primary power train,

the third epicyclic gearset (141) being provided with a sun gear (76; PC, Fig. 3), a ring gear (177; Cc, Fig. 3) and a planet carrier (168) integral with a second brake (169);

the fourth epicyclic gearset (142) being provided with a planet carrier (163), which couples its sun gear (178) to its ring gear (179),

the sun gear (176) of the third epicyclic gearset (141) being integral with the ring gear (179) of the fourth epicyclic gearset (142), and the ring gear (177) of the third epicyclic gearset (141) being integral with the sun gear (178) of the fourth epicyclic gearset (142);

the shaft (158) of the gearbox (156) being terminated at its other end relative to the internal combustion engine (150) by a pinion (171) connected to the second electric machine (152);

the sun gear (162) of the second epicyclic gearset (137; Fig. 3) of the compound gearset carrying an external toething (165), which is coupled to a pinion (167) integral with the shaft of the rotor of the first electric machine (151) of the electric variator.

8 - A transmission according to claim 7, characterized in that the sun gear (176) of the third epicyclic gearset (141) as well as the ring gear (179) of the fourth epicyclic gearset are made integral with a first lining

of a brake (170; 144', Fig. 3), the other lining of the brake (170) being integral with the gearbox case and a brake actuator (not illustrated) making it possible to activate or not activate braking by bringing the two linings together in response to an adjusting signal from the transmission's mode-of-operation controller (135, 149).

9 - A transmission according to claim 7, characterized in that the planet carrier (168) of the third epicyclic gearset (ps, 141), integral with the ring gear (179) of the fourth epicyclic gearset (cb, 142), is integral with a first lining of a brake (169), the other lining of brake (169) being integral with the gearbox case, and a brake actuator (not illustrated), associated with the brake (169) of the planet carrier (168), making it possible to activate or not activate braking thereof by bringing the two linings together in response to an adjusting signal from the transmission's mode-of-operation controller (135, 149).

10. A transmission according to at least one of the preceding claims, characterized in that it is provided with an operating controller (135) provided with:

- a controller (146) of the operating point of the motive power unit as a function of predetermined stresses;
- a controller (147) of the operating point of the internal combustion engine (130), which controller receives an operating point target value from the controller (135) and generates adjusting signals suitable for actuators for determination of the operating point of the internal combustion engine (130);
- an operating controller (148) of the first and second electric machines (131 and 132) in such a way that, for each machine, there are determined its mode of operation, either as a motor or generator, its speed of rotation and/or its torque or else its armature voltage and/or its armature current, especially in relation with a device for

management of an electrical energy accumulator, the said controller (148) receiving a target value of the operating point from the controller (135) and producing suitable adjusting signals for the pilot-control circuits of the electric machines;

- a transmission-mode-changing controller (149), which determines the open or closed state of the first brake (144) and/or of the second brake (144') in such a way that one mode among at least two modes of operation of the infinitely variable transmission is selected by an adjusting signal of the controller (135).

11. A power-splitting infinitely variable transmission with two modes of operation, wherein the constituent elements thereof are distributed between two power trains connecting the internal combustion engine (1) in parallel manner to the wheels (3) of the vehicle, these means including two epicyclic gearsets (5, 6), two electric machines (2, 4), one reducing stage (7) and adjusting means that distribute the power between the two power trains differently depending on the mode of operation thereof, characterized in that it is provided with a third epicyclic gearset (47) in series with one of the two epicyclic gearsets (45, 46) on one of the two power trains, the said third epicyclic gearset (47) cooperating with the said adjusting means (48, 50) in such a way that, in a first mode of operation, all the elements (c, p, ps) of the third gearset (47) are spinning at the same speed.

12. A transmission according to claim 11, characterized in that, on a first power train, the vehicle wheels (43) are connected via a reducing stage (53) to the planet carrier of the first epicyclic gearset (45), the sun gear of which is connected directly to the shaft of the internal combustion engine (41), and in that the second power train (51, 47, 46, 44) is coupled to the first epicyclic gearset (45) by its ring gear.

13. A transmission according to one of claims 11 or 12, characterized in that the ring gear (c) of the third epicyclic gearset (47) is connected

to the ring gear of the second epicyclic gearset (46), and in that the sun gear (p) of the third epicyclic gearset (47) is integral both with the ring gear of the first epicyclic gearset (43) and with the rotor of the first electric machine (44).

14. A transmission according to claim 13, characterized in that the planet carrier of the second epicyclic gearset (46) is connected to the internal combustion engine (41) via a reducing stage (51), the reduction ratio of which can be matched to the mechanical power and to the optimal speed of rotation of the internal combustion engine (41) to which it is connected.

15. A transmission according to claim 14, characterized in that the sun gear of the second epicyclic gearset (46) is connected to the rotor of the second electric machine (42).

16. A transmission according to claim 13, characterized in that, by activation of the mode-changing system, the planet carrier of the third epicyclic gearset (47) is immobilized on the case (50) via a brake (48) disposed between the case (50) and the planet carrier (ps) of the third epicyclic gearset (47).

17. A transmission according to claim 16, characterized in that the planet carrier (ps) of the third epicyclic gearset (47) is connected to its sun gear (p) via a clutch (49) adjusted by the mode-changing system.

18. A transmission according to one of claims 11 to 17, characterized in that the second and third epicyclic gearsets are provided with a common ring gear (75), in that the planet carrier (74) of the third epicyclic gearset (47) spins freely around the shaft of its sun gear (76), the said shaft being connected to the shaft carrying the ring gear of the first epicyclic gearset (45), in that the planet carrier (81) of the second epicyclic gearset (46) spins freely around the shaft of its sun gear (79), the said shaft being connected to the shaft of the rotor of the second electric machine (42), and in that the planet carrier (68) of the first

epicyclic gearset (45) spins freely around the shaft (60) of its sun gear, the said shaft (60) being integral at its two ends with the engine shaft of the internal combustion engine (41) and of the sun gear.

19. A transmission according to claim 18, characterized in that the first electric machine (44) is disposed outside the common axis of the internal combustion engine (41) and of the first, second and third epicyclic gearsets (45), 46 and (47) respectively and of the second electric machine (42), its rotor shaft being integral with a pinion (72) engaged on an external toothed ring (71) of the ring gear of the first epicyclic gearset (45).

20 - A transmission according to at least one of claims 11 to 19, characterized in that it is provided with an operating controller (80), which is provided with:

- a controller (81) of the operating point of the motive power unit as a function of predetermined stresses;
- a controller (82) of the operating point of the internal combustion engine (41) that receives an operating point target value from the controller (81) and generates adjusting signals suitable for actuators for determination of the operating point of the internal combustion engine (41);
- an operating controller (83) of the first and second electric machines (44) and (42) respectively in such a way that, for each machine, there are determined its mode of operation, either as a motor or generator, its speed of rotation and/or its torque or else its armature voltage and/or its armature current, especially in relation with a device for management of an electrical energy accumulator, the said controller (83) receiving a target value of the operating point from the controller (81) and producing suitable adjusting signals for the pilot-control circuits of the electric machines;

- a transmission-mode-changing controller (84), which determines the open or closed state of the clutch (49) and/or of the brake (48) in such a way that one mode among at least two modes of operation of the infinitely variable transmission is selected by an adjusting signal of the controller (81).

21. A power-splitting infinitely variable transmission with two modes of operation, wherein the constituent elements thereof are distributed between two power trains connecting the internal combustion engine (1) in parallel manner to the wheels (3) of the vehicle, these means including two epicyclic gearsets (5, 6), two electric machines (2, 4), one reducing stage (7) and adjusting means that distribute the power between the two power trains differently depending on the mode of operation thereof, characterized in that it is provided with a first compound gearset (TA), which makes it possible to connect the internal combustion engine (230) to the vehicle wheels (233) along a first power-splitting train, and with a simple gearset (TB), which makes it possible to achieve power splitting, as well as with a second compound gearset (TC), in such a way as to achieve a system for changing mode between at least two modes of operation of the infinitely variable transmission.

22 - A transmission according to claim 21, characterized in that the first compound gearset (TA) is provided with a first epicyclic gearset (238), to which the internal combustion engine (230) is connected via its sun gear (P1), the planet carrier (ps) of the first epicyclic gearset (238) being connected to a reducing stage (239), the output of which is connected to the driving wheels (233) of the vehicle and to the planet carrier of a second epicyclic gearset (237) of the first compound gearset (TA), the ring gears of the first and second epicyclic gearsets (238) and (237) respectively being connected together, and their

common movement being transmitted at a coupling over the secondary power-splitting train.

23 - A transmission according to claim 22, characterized in that the sun gear (P2) of the second epicyclic gearset (237) is itself connected to the planet carrier (ps) of an epicyclic gearset (TB), whose sun gear (p) is connected to the rotary shaft of a second electric machine (232), a first electric machine (231) of the electric variator of the transmission being coupled via its output shaft to a reducing stage (240), connected both to the ring gears of the first and second epicyclic gearsets (238) and (237) respectively of the first compound gearset (TA), as well as to the ring gear (C1) of a first epicyclic gearset (231) of a second compound gearset (TC), which is also provided with a second epicyclic gearset (236) and which is configured in such a way that the planet carriers and the sun gears of its two epicyclic gearsets (231, 236) are coupled to one another, in that the planet carriers (PS) of the second compound gearset (TC) are temporarily integral with a frame or chassis (244) by means of a first brake (244), while the ring gear (C2) of the second epicyclic gearset (236) of the second compound gearset (TC) can be made integral with the chassis or fixed point (245) by means of a second brake (244'), and in that the sun gears of the epicyclic gearsets (231, 236) of the compound gearset TC are connected to the ring gear of the epicyclic gearset (TB).

24 - A transmission according to one of claims 22 or 23, characterized in that the output shaft (250) of the internal combustion engine (230) is aligned with the common shaft (251) of rotation of the primary compound gearset (TA), of the compound mode-changing gearset (TC) and of the simple gearset (TB) for recombination of the two splitting trains,

in that the internal combustion engine (230) is directly connected without intermediate reducing stage via this shaft (250) to the sun gear (PA₁) of the first epicyclic gearset (238, Fig. 2) of the first compound gearset (TA), the planet carrier (PS_A) being double and common to the two epicyclic gearsets (237, 238) of the first compound gearset (TA), the planet carrier (PS_A) being spun on the sun gear (PA₁) of the epicyclic gearset (238; Fig. 2), fixed at the end of the shaft (250) of the internal combustion engine (230), and spinning on the sun gear (PA₂) of the second epicyclic gearset (237; Fig. 2) of the first compound gearset (TA), fixed on a first part of the shaft (251), a second part of which is aligned with the shaft (250) and carries the planet carrier (PS_B) of the simple gearset (TB), the common shaft (251) carrying the following components, which can rotate freely on two bearings:

- the ring gear (CA), common to the two epicyclic gearsets (238, 237) of the first compound gearset (TA), and the ring gear (CC1) of the first epicyclic gearset (231) of the second compound gearset (TC);
- the sun gear (PC) of the second compound gearset (TC), which is integral with the ring gear (CB) of the simple gearset (TB).

25 - A transmission according to claim 24, characterized in that the ring gear (CA) of the two epicyclic gearsets (238, 237) of the first compound gearset (TA) is provided with a single toothing to drive a single pinion of the sun gear (SA) mounted on the planet carrier (PS_A), each planet gear (SA) of the planet carrier (PS_A) being double, meaning that it carries:

- a first pinion engaged between the sun gear (PA₁) of the epicyclic gearset (23) and the single toothing, in this case internal, of the ring gear (CA), common to the two epicyclic gearsets;

- a second pinion integral with the first pinion via their common spindle and engaged on the sun gear (PA₂) of the second epicyclic gearset (237) of the first compound gearset (TA);

in that the planet carrier (PS_A) of the first compound gearset (TC) is mounted to rotate freely on a suitable bearing disposed on the output shaft (250) of the internal combustion engine (230) and is integral with a toothed gear engaged on a pinion integral with the vehicle wheels (233).

26 - A transmission according to claim 25, characterized in that the ring gear (CA) also carries an external toothing, which is engaged with a pinion (253) mounted at the end of the shaft of the rotor of the first electric machine (231) of the electric variator.

27 - A transmission according to claim 26, characterized in that the sun gear (PC) common to the two epicyclic gearsets (231, 236) of the second composite gearset (TC) is provided with a single external toothing to drive a single pinion of the planet gear (SC) mounted on the planet carrier (PS) of the second compound gearset (TC), each planet gear (SC) of the planet carrier (PS) being double, meaning that it carries:

- a first pinion engaged on the sun gear (PC) on the one hand and on an internal toothing of the ring gear (CC1) of the epicyclic gearset (231) integral with the common ring gear (CA) of the first compound gearset (TA);

- a second pinion, integral with the first pinion via their common spindle and engaged on an internal toothing of the ring gear (CC2) of the second epicyclic gearset (236) of the second compound gearset (TC);

and in that the planet carrier (PSC) of the second compound gearset (TC) is mounted to rotate freely between the sun gear (PC) and the ring gear (CC1) of its first epicyclic gearset (231).

28 - A transmission according to claim 27, characterized in that the shaft (251) carries the planet carrier (PS_B) of the simple gearset (TB), which spins on the sun gear (PB), whose shaft (252), aligned with the shafts (251, 250), is connected to the rotor of the second electric machine (232).

29 - A transmission according to claim 28, characterized in that the mode-changing system is provided with:

- a first brake (244), which is provided with a first lining integral with the ring gear (CC2) of the second epicyclic gearset (236) of the second compound gearset (TC) and a second lining integral with the case (245) of the gearbox, a brake actuator being disposed between the two linings in such a way that, in response to the adjusting signal from transmission-mode-changing controller (249), the first brake (244) is either opened or clamped;

- a second brake (244'), which is provided with a first lining integral with the planet carrier (PSC) of the second compound gearset (TC) and a second lining integral with the case (245) of the gearbox, a brake actuator being disposed between the two linings in such a way that, in response to the adjusting signal from the transmission-mode-changing controller (249), the second brake (244') is either opened or clamped;

30. A transmission according to one of claims 21 to 29, characterized in that it is provided with an operating controller (235) connected by a bus (B) to different sensors of the state of operation of the vehicle as well as to sensors for detecting the intent of the operator and to a plurality of controllers, which are provided with:

- a controller (246) of the operating point of the motive power unit as a function of predetermined stresses;
- a controller (247) of the operating point of the internal combustion engine (230), which controller receives an operating point target value from the operating controller (235) and generates adjusting signals suitable for actuators for determination of the operating point of the internal combustion engine (230);
- an operating controller (248) of the first and second electric machines (231) and (232) respectively in such a way that, for each machine, there are determined its mode of operation, either as a motor or generator, its speed of rotation and/or its torque or else its armature voltage and/or its armature current, especially in relation with a device for management of an electrical energy accumulator, the said controller (248) receiving a target value of the operating point from the operating controller (235) and producing suitable adjusting signals for the pilot-control circuits of the electric machines in order to determine their respective operating points according to a four-quadrant current-voltage rule I;
 - a transmission-mode-changing controller (249), which determines the open or closed state of the first brake (244) and/or of the second brake (244') in such a way that one mode among at least three modes of operation of the infinitely variable transmission is selected by an adjusting signal of the operating controller (235), among which:
 - in the first mode of operation, the brake (244) blocks the planet carrier (PS) of the two epicyclic gearsets (231, 236) of the second compound gearset (TC), the ring gear (C) of the second epicyclic gearset (236) spins freely, and the gearset (TC) functions as a simple gearset

composed of the ring gear of first epicyclic gearset (231) of the common planet carrier (PS) and of the common sun gear (P);

- in a second mode of operation, the mode-changing system is disposed in such a way that the two brakes (244, 244') are both clamped, all elements of the compound gearset (TC) being blocked in such a way that the two electric machines (231, 232) are directly connected to the primary power-splitting train, and either one or the other or both can operate both as a generator and as a motor;
- in a third mode of operation, the first brake (244) is open and the second brake (244') is clamped, in such a way that the ring gear (C) of the second epicyclic gearset (236) is braked and functions as a support point.